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New Phase Diagram of the Piezoelectric Relaxor PZN-xPT.

D. La-Orauttapong, J. Toulouse (Lehigh U.), B. Noheda, D. Cox, G. Shirane (Physics, BNL), Z. Ye (SFU, Canada), P Gehring (NIST), S-E. Park (Penn. U)

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Introduction: The single-crystal solid solution of the relaxor $Pb(Zn_{1/3}Nb_{2/3})O_3$ and ferroelectric $PbTiO_3$, known as PZN-x%PT, is being considered as a promising candidate for the next generation of electromechanical transducers, in sonars, hydrophones, micropositioners, etc.[1]. At high temperatures, the material has the perosvkite structure. As the temperature is lowered, a ferroelectric/relaxor phase transition takes place [2]. Close to pure $Pb(Zn_{1/3}Nb_{2/3})O_3$ and for Ti contents below about 9%, the low temperature phase is rhombohedral (R3m) and the material is a relaxor. For higher Ti contents, the material becomes tetragonal (P4mm) and the relaxor character decreases (and finally vanishes for higher Ti concentrations). The boundary in between the rhombohedral and tetragonal phases is called "morphotropic phase boundary" (MPB). The similarity of this phase diagram and that of PZT[3] and the fact that rhombohedral PZN-xPT single crystals show its most remarkable piezoelectric properties when poled along the <100> directions[1], point towards the existence of a low symmetry phase in between the R3m and the P4mm phases, similar to that found in PZT[3].

Methods and Materials: We have performed high-resolution powder diffraction measurement in the analyzer geometry on PZN-xPT of various compositions, x, around the MPB, as a function of temperature, in order to establish the phase diagram. The samples were grown by the high temperature flux method as described in ref. [1]. A small piece of each crystal was crushed and sieved between 38-44μm. 0.2mm capillaries were loaded with those powders.

Results and conclusions: We have indeed found a low symmetry phase between the R3m and P4mm PZN-xPT phases, with orthorhombic symmetry [4-5], as shown in Fig. 1. The orthorhombic unit cell can be considered as a monoclinic Pm cell in the limit of $a_m=c_m$. We have established a new phase diagram of PZN-xPT, as shown in Fig. 2.

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References: [1] S.E. Park and T. Shrout, J. Appl. Phys. 82, 1804 (1997); [2] J. Kuwata et al., Jpn. J. Appl. Phys. 21, 1298 (1982); [3]B. Noheda et al., Phys Rev. B 63, 14103 (2001); [4] D.E. Cox. et al., Appl. Phys. Lett. 79, 400 (2001); [5] D. La-Ourattapong et al., (submitted). <cond-mat/0108264>

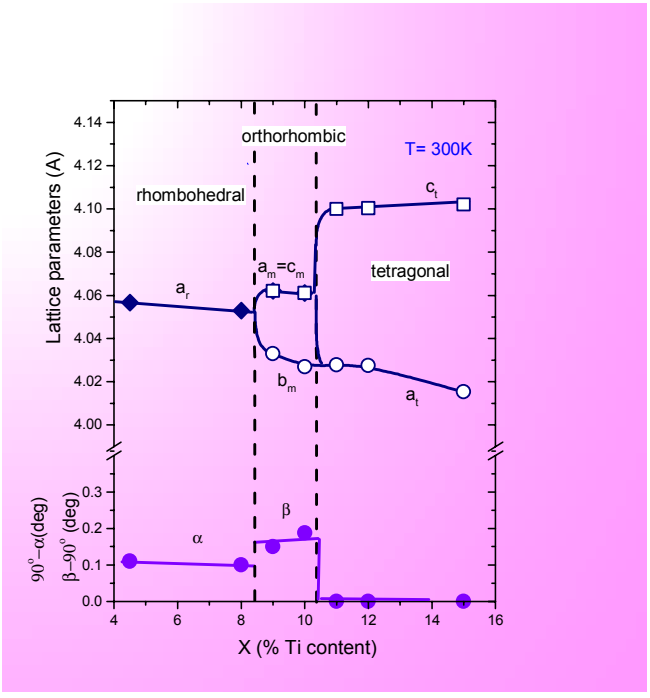

Figure 1. Composition dependence of the PZN-xPT lattice parameters at T= 300K

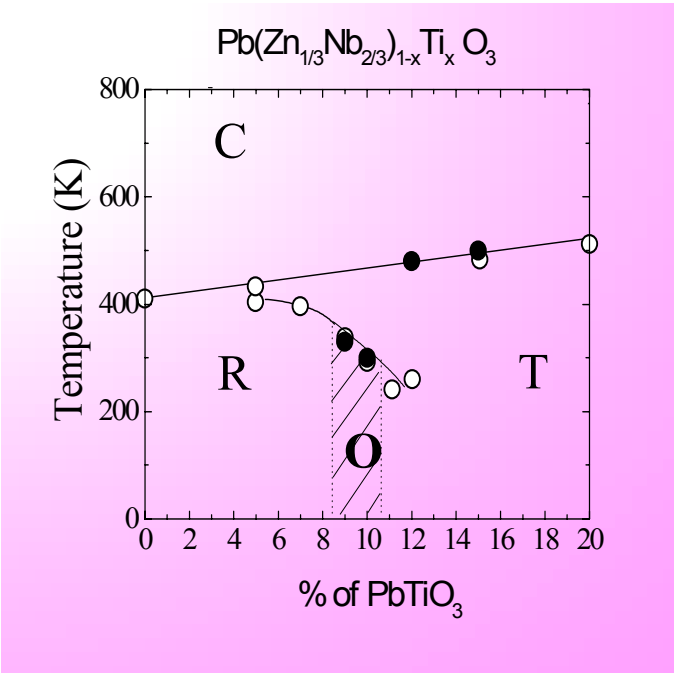

Figure 2. Phase diagram of PZN-xPT [5].